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Research Article

Presbyopia-Correcting IOL and Glaucoma

Dzhashi BG and Balalin SV*

S. Fyodorov Eye Microsurgery Federal State Institution, Volgograd Branch, Russia

***Corresponding Author:** Sergei Balalin, Professor of the Department of Ophthalmology, Institute of Continuing Medical and Pharmaceutical Education, Volgograd State Medical University, Head of Scientific Department, S. Fyodorov Eye Microsurgery Federal State Institution, Volgograd Branch, Volgograd, Russia.

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Abstract

IOL with in-depth focus is a modern vector for the development of cataract surgery. The aim of this work was to analyze the results of implantation of this group of IOLs in patients with glaucoma-associated cataracts. In the study groups of patients (84 eyes), high functional results were obtained. It was concluded that intraocular lenses with deep focus can be used to correct aphakia in patients with glaucoma-associated cataracts.

Keywords: *Cataract; Glaucoma; Deep Focus IOL*

Introduction

The refractionalization of phacosurgery requires the optimization of functional outcomes. Modern intraocular lenses (IOLs) with complex optics provide to create a single-elongated focal point which enhances the patient's depth of focus, continuous viewing area. However, high-tech intraocular lenses (AT-IOLs) are quite demanding on the conditions of implantation. Thus, multifocal IOLs are positioned as lenses that provide patients with high visual functions at various distances: far, middle, and near. The operation of such IOLs is based on the redistribution of the light flux to focal points, which provides vision at different distances. In this case, various optical effects may occur, which significantly reduce patient satisfaction with the results of cataract surgery [1,3,6-8,11,12,17,20,22]. Intraocular lenses for the correction presbyopia provide patients with visual functions at far and medium distances without guaranteeing high near vision, which in the age of gadgets is sufficient for a comfortable life [9,13,14,16,19,21]. This range is very wide and includes groups of monofocal plus lenses, extended depth of focus IOL, extended range of vision and hybrid IOL. Their active use in the practice of ophthalmic surgeons makes it possible to see and evaluate the functional results in patients. According to the literature, the level of negative optical phenomena in such patients is significantly lower than after implantation of multifocal IOLs [1-4,6,9,11,12,14,16,19]. Cataract associated with glaucoma introduces its own adjustments to the choice of intraocular lenses in the correction of aphakia in this group of patients. Glaucoma is often accompanied by uveo-, phaco-, and zonolopathy, which limits the use of multifocal IOL. Insufficient pupil excursion reduces the effectiveness of pupillary-dependent multifocal IOL implantation. Zonulopathy, and as a result, subluxation of the lens, can contribute to the strengthening of negative optical phenomena. Implantation of the IOL with above structure may become the method of choice in this group of patients [3,10,11,13,15,18,20].

Aim of the Study

The aim of our study was to analyze the results of presbyopia-correcting IOL implantation in patients with glaucoma.

Materials and Methods

We analyzed the results of cataract phacoemulsification in 72 patients (84 eyes) with cataract associated with glaucoma and pseudoexfoliative syndrome with AT-IOL implantation. All patients were operated on at the Volgograd branch of the Eye Microsurgery named after Academician S.N. Fedorov of the Ministry of Health of Russia. The gender distribution was as follows: 33 men, 39 women. The average age of the observed patients was 64.1 ± 4.6 years. Of the concomitant diagnoses in the anamnesis, glaucoma, pseudoexfoliative syndrome (PES), dry macular degeneration were recorded. All patients were divided according to the stage of the glaucoma process into 3 groups. The first group of the study included cases of open-angle, closed-angle or mixed glaucoma in the initial stage (I) of the glaucoma process - 41 eyes. The second group included cases of open-angle, closed-angle or mixed glaucoma in advanced stage (II) glaucoma - 27 eyes. The third group of the study included cases of open-angle, closed-angle or mixed glaucoma in advanced stage (III) glaucoma. Additional breakdown into groups of patients based on the opening of the angle of the anterior chamber was not performed due to the small filling of individual groups. Also, we did not perform a division of the study cases on the basis of the implanted IOL model, each of which belonged to the group of monofocal plus lenses, extended Depth of focus IOL, extended range of vision or hybrid IOL. All patients underwent a standard preoperative examination, including visometry, tonometry, tonography, keratorefractometry, visocontrastometry, and automatic perimetry. The studies were repeated in the postoperative period (1 day, 1 month and 6 months after the intervention). For a subjective assessment of the quality of vision, a quantitative study of functional disorders associated with vision, and the performance of visual tasks, a postoperative questionnaire was performed using the Visual Function - 14 (VF-14) questionnaire [3,5,7,11]. Preoperative examination data are presented in table 1.

Groups Options	Stage glaucoma		
	I (41 eyes)	II (27 eyes)	III (16 eyes)
UCVA preop	0.14 ± 0.14	0.15 ± 0.16	0.13 ± 0.11
BCVA preop	0.18 ± 0.52	0.27 ± 0,19	0.21 ± 0.14
SE preop	-0.95 ± 1.64	-1.01 ± 1.53	-1.09 ± 1.39
IOP preop, mmHg	18.6 ± 1.63	19.2 ± 1.97	19.3 ± 1.93
C, мм^3/ mmHg *min	0.17 ± 0.04	0.16 ± 0.04	0.13 ± 0.02
MD, dB	-4.9 ± 0.64	-9.2 ± 1.41	-15.6 ± 2.32
Target refraction preop	-0.0005 ± 0.24	-0.06 ± 0.26	-0.04 ± 0.24

Table 1: *Preoperative parameters in study groups, 84 eyes, M ± σ.*

Patients who had not previously undergone surgical treatment of glaucoma were on drug antihypertensive therapy (mono or combined) with a number of beta-blockers and/or carbonic anhydrase inhibitors. Taking into account the risks of postoperative hypertension and in preparation for the next stage of surgical treatment, antihypertensive therapy was remained in the same state. Cataract phacoemulsification (PEC) was performed according to the Phaco chop method (Nagahara), with a small tunnel access of 2.2 mm, using the Centurion Vision System (Alcon, USA). Patients were implanted with one of 4 IOL models: TECNIS Symfony (Johnson & Johnson), EDEN (SAV-IOL), LENTIS Comfort LS 313 MF15 IOL (Teleon), AcrySof® IQ Vivity (Alcon). After completion cataract phacoemulsification, a solution of an antibiotic and a steroid preparation was administered subconjunctivally. As part of the statistical analysis, taking into account the non-normal distribution, a non-perimetric analysis of the results obtained between dependent variables was applied (Wilcoxon test, T). When conducting statistical analysis between independent groups, the Mann-Whitney test (U) was applied.

Results

No complications were noted during the surgical treatment and in the postoperative period. All patients were prescribed standard postoperative instillation therapy: an antibiotic solution for 2 weeks, a non-steroidal anti-inflammatory drug solution, and a tear substitute.

Groups Options	Stage glaucoma		
	I	II	III
UCVA postop	0.76 ± 0.22	0.73 ± 0.26	0.27 ± 0.29
BCVA postop	0.76 ± 0.21	0.74 ± 0.25	0.6 ± 0.3
IVA	0.49 ± 0.12	0.46 ± 0.15	0.38 ± 0.17
SE postop	-0.05 ± 0.22	-0.05 ± 0.28	0
IOP postop, mmHg	18.07 ± 1.13	18.25 ± 1.45	18.63 ± 1.96
C, mm^3/ mmHg *min postop	0.19 ± 0.04	0.19 ± 0.04	0.17 ± 0.02
MD, dB	-4.8 ± 0.61	-9.2 ± 1.38	-15.4 ± 2.28
Refraction postop	-0.04 ± 0.19	-0.05 ± 0.16	-0.03 ± 0.12

Table 2: *Postoperative parameters in study groups, 84 eyes, M ± σ.*

Antihypertensive therapy remained the same at a stable level of IOP and was corrected in case of its imbalance. In all cases of surgical treatment, patients were examined on the first day, 1 month and 6 months after surgery. The summary table presents the data of the postoperative examination in groups.

The study showed a regular improvement in visual functions in the postoperative period in all observation groups. It is also possible to note stably normal values of intraocular pressure by the end of the period of postoperative observation, a significant improvement in hydrodynamic parameters.

Options	M	σ	T	P
UCVA	0.14	0.14	0.0	0.000000
UCVA postop	0.76	0.21		
BCVA	0.18	0.3	6.0	0.000000
BCVA postop	0.76	0.22		
SE	0.95	1.66	55.5	0.002
SE postop	-0.05	0.22		
IOP,	18.6	1.65	156.0	0.59
IOP postop, mmHg	18.07	1.13		
C, mm^3/mmHg *min	0.17	0.04	192.5	0.006
C, mm^3/mmHg *min postop	0.19	0.04		
Target refraction	0.0005	0.12	313.5	0.13
Refraction postop	-0.04	0.19		

Table 3: *Postoperative parameters in the 1st study group, 41 eyes, M ± σ.*

Perimetric indicators showed stability during the observation period. In all cases, a hit in the calculated refraction was recorded. Attention is drawn to intermediate visual acuity (IVA): its value correlates with the stage of the glaucoma process and reaches values from 0.38 ± 0.17 to 0.49 ± 0.12 in patients with glaucoma in the postoperative period. If we consider the indicators in more detail, it is worth referring to individual groups of the study. Thus, the first group is represented by cases of treatment of patients in the initial stage of the glaucoma process, when the changes are still shallow and the ophthalmic surgeon can expect to achieve visual functions close to the results in eyes without glaucoma.

Thus, in patients of the first group of the study, a significant increase in distance visual acuity was noted (UCVA = 0.76 ± 0.21) with falling into the planned refraction. Significant stability of intraocular pressure indicators was noted, as well as an improvement in the coefficient of ease of outflow of intraocular fluid. Table 4 shows the results of the analysis of postoperative parameters of the second group of the study.

Options	M	σ	T	P
UCVA	0.15	0.17	0.0	0.000000
UCVA postop	0.73	0.26		
BCVA	0.27	0.19	0.0	0.000008
BCVA postop	0.73	0.26		
SE	-1.02	0.00	7.0	0.004
SE postop	0.00	0.00		
IOP, mmHg	19.2	2.0	37.5	0.06
IOP postop, mmHg	18.19	1.47		
C, mm^3/mmHg *min	0.16	0.04	88.46	0.00
C, mm^3/mmHg *min postop	0.19	0.038		
Target refraction	0.06	0.26	48.15	1.0
Refraction postop	-0.05	0.17		

Table 4: *Postoperative parameters in the 2nd study group, 27 eyes, M ± σ.*

An analysis of the results of treatment in the second group of the study, in which patients underwent IOL implantation during cataract phacoemulsification with concomitant advanced stage glaucoma, also showed a significant improvement in visual functions (0.73 ± 0.26), a decrease in IOP (from 19.2 ± 2.0 to 18.19 ± 1.47 mm Hg) and improvement in the ease of outflow of intraocular fluid (from 0.16 ± 0.04 to 0.19 ± 0.04 mm^3/mm Hg*min). The indicators of the third group of the study are presented in table 5.

Options	M	σ	T	P
UCVA	0.13	0.11	0,0	0.000004
UCVA postop	0.27	0.32		
BCVA	0.21	0.15	0,0	0.78
BCVA postop	0.6	0.3		
SE	-1.09	1.44	7.0	0.02
SE postop	0.00	0.00		
IOP, mmHg	19.31	1.99	37.5	0.58
IOP postop, mmHg	18.62	2.02		
C, mm^3/mmHg *min	0.14	0.02	88.46	0.002
C, mm^3/mmHg *min postop	0.17	0.03		
Target refraction	-0.04	0.25	48.15	0.8
Refraction postop	-0.03	0.125		

Table 5: Postoperative parameters in the 3rd study group, 16 eyes, M ± σ.

An analysis of the results of treatment of patients in the third group of the study also demonstrated an improvement in distance visual acuity (BCVA = 0.6 ± 0.3 by the end of the observation period), stability of intraocular pressure. Taking into account the nature of the intervention in the study groups, a study was conducted of the standard evaluation criteria in the practice of refractive surgery: efficacy, predictability, safety [4]. Efficacy was assessed as the ratio of UCVA after surgery to preoperative BCVA values. In all groups of the study, a high efficiency of the intervention was noted. The ratio of indicators at different stages of glaucoma is clearly presented in the form of diagrams in figure 1-3.

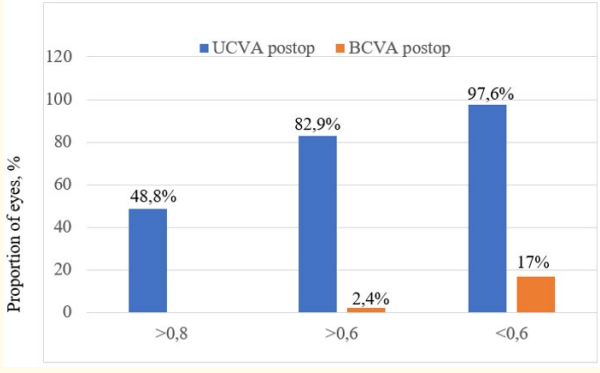

Figure 1: *Efficiency, stage I glaucoma (41 eyes).*

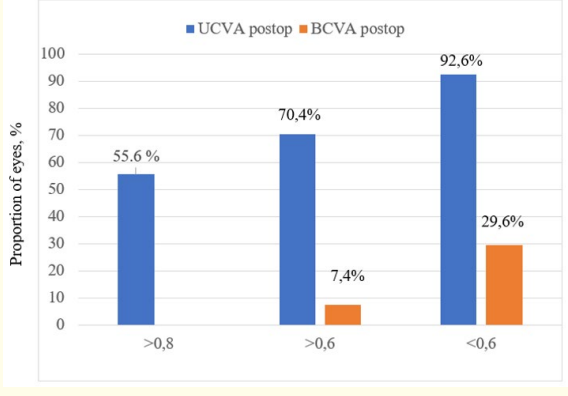

Figure 2: *Efficiency, stage II glaucoma (27 eyes).*

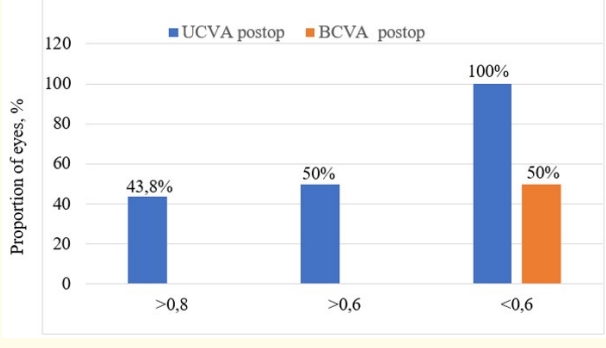

Figure 3: *Efficiency, stage III glaucoma (16 eyes).*

Predictability was assessed as the proportion of eyes with a refraction deviation of ± 0.5 diopters relative to the target refraction in the groups and was more than 95% (where the postop SE deviation is no more than 0.5d from the planned one) (Figure 4).

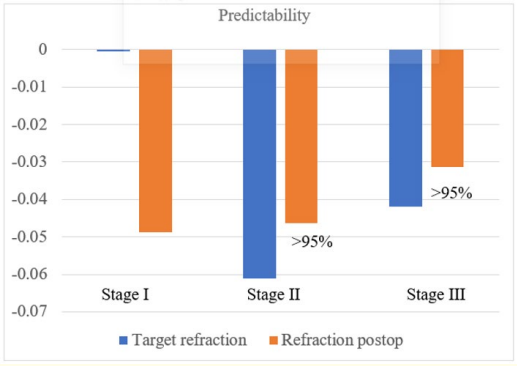

Figure 4: *Predictability of refraction after surgery in patients at various stages of glaucoma, 84 eyes.*

The safety of the technique is usually assessed by the loss of lines in postoperative visometry compared to preoperative BCVA values. In this study, no vision loss was observed in any case compared to preoperative values: 100% with no line loss. Implantation of high-tech IOLs often leads to a decrease in spatial contrast sensitivity and reduces patient satisfaction with the results of the treatment. Contrast sensitivity is an important visual function that characterizes the quality of vision and the ability to distinguish the details of objects that differ in tone saturation. The sensitivity of a healthy person to changes in contrast is maximum in the range of spatial frequencies from 4 to 10 cycle/deg. The greatest decrease in patients with glaucoma is observed in the range of low spatial frequencies [4,10,11,13,15,18].

For visocontrastometry in this study, the Zebra computer program was used. To determine the threshold contrast in the program, differently colored sinusoidal gratings of vertical and horizontal orientation with spatial frequencies from 0.5 to 16 cycle/deg were used. The measurements were performed monocularly, under mesopic conditions. According to the conducted visocontrastometry, there was no significant difference in achromatic contrast sensitivity in patients before and after surgery in the spatial frequency range from 0.5 to 16 cycle/deg. The data ranged from 10 to 50 dB in direct proportion to frequency. The figure below shows the average results of the study.

A questionnaire was used to assess the subjective satisfaction of patients with the result and to quantitatively study functional disorders associated with vision. Patients were asked to answer questions according to the Visual Function - 14 (VF-14) questionnaire, which allow assessing the ability to perform various visual tasks. The standard questionnaire contains 18 questions on 14 areas of the patient's vision-related activities. The total number of points scored during the survey determines the level of patient satisfaction.

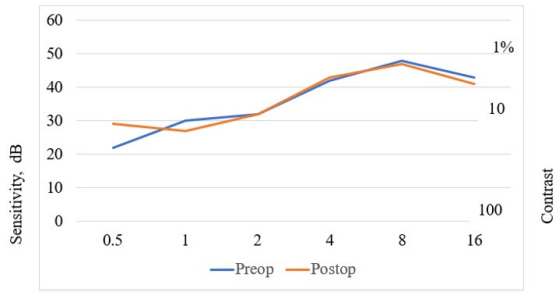

Figure 5: *Study of spatial contrast sensitivity, dB.*

Figure 6 demonstrates the subjective assessment of the results of surgical intervention with IOL implantation with deep focus in eyes with cataracts associated with glaucoma of various stages, expressed in points.

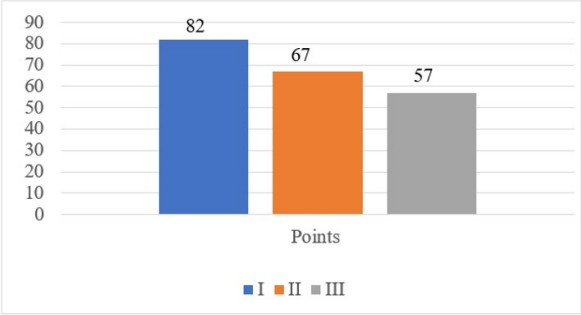

Figure 6: *Questionnaire results after IOL implantation with in-depth focus on eyes with cataracts associated with glaucoma of various stages, 84 eyes.*

It should be noted that the patients of the first group of the study (the initial stage of the glaucoma process) demonstrate the greatest subjective satisfaction, and the minimum - the patients of the third group, who were diagnosed with advanced glaucoma. The severity of optical phenomena is another important characteristic of the postoperative state [1-4,8,9,11-14]. The occurrence of this phenomenon is associated with the features of optical systems. Most often, ophthalmic surgeons encounter halo (circles of light scattering when looking at a light source), flare (flashes, sparkling), flashes (glimmers), glare (dazzlingly bright light), light streaks (light flickering). Of the reported effects, glaucoma patients in our study mentioned flare and glare. The percentage distribution by study groups is shown in the diagram in figure 7. It should be noted that in this study, the highest number of photopic phenomena (11 cases, 13%) were presented by patients with glaucoma at the late stage of glaucoma process, and the lowest number of complaints (6 cases, 7%) were presented by patients with initial glaucoma.

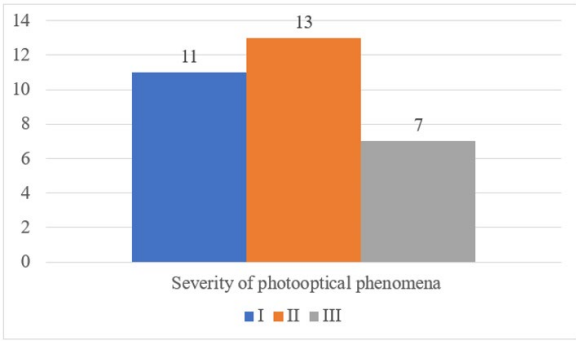

Figure 7: *Percent distribution of photopic phenomena in patients at various stages of glaucoma, 84 eyes.*

Discussion

Data from the analysis of the results of IOL implantation with Presbyopia-correcting IOL in the literature are quite contradictory [1-24]. A number of authors note high results and a low level of loss of contrast sensitivity, as well as a small number of photopic phenomena. However, there is also evidence of a decrease in contrast sensitivity and a rather high level of complaints about optical effects in patients of this group. When evaluating the results of treatment in patients with glaucoma, for the correction of aphakia, in whom AT-IOLs are used, of course, an even deeper analysis is required, based on the allocation of groups based on not only the stage of the glaucoma process, but also the degree of openness of the anterior chamber angle, as well as implanted IOL models. The group of monofocal plus lenses, extended depth of focus IOL, extended range of vision and hybrid IOL is very diverse and the principles of operation of each of the known models differ significantly. So, TECNIS Symfony (Johnson & Johnson), powered by a patented echelette design, promises to increase depth of focus without sacrificing contrast sensitivity. This effect can be explained, among other things, by the diffractive nature of the IOL optics. However, diffractive lenses cannot guarantee the leveling of photopic phenomena. Intraocular lenses, the principle of which is based on a refractive grating (AcrySof® IQ Vivity Alcon), reduce the risk of unwanted optical effects, however, working with spherical aberrations without diffraction rings based on the patented X-Wave technology cannot guarantee us maintaining a sufficient level of contrast sensitivity. Hybrid IOLs (EDEN, SAV-IOL) combine both the advantages of the described systems and their inherent disadvantages. Thus, averaging the results of implantation of various models of intraocular lenses of the IOL group with deep focus is rather arbitrary. Long-term studies are required to form clear indications for the implantation of a specific IOL model in glaucoma of various types and at various stages. A certain difficulty is the recruitment of large groups of patients with glaucoma for AT-IOL implantation. However, already now, on the basis of the conducted studies, we can speak of this group of IOLs as promising for glaucoma patients.

Conclusion

Intraocular lenses of the group monofocal plus lenses, extended depth of focus IOL, extended range of vision and hybrid IOL with deep focus show high refractive results and subjective satisfaction with results above average in patients with glaucoma and can be used in the correction of aphakia during cataract surgery.

Disclosure

None of the authors has a financial or proprietary interest in any material or method.

Conflict of Interest

There is no conflict of interest.

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